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PROPOSAL FOR GALACTIC AND SOLAR COSMIC RAY STUDIES ON OGOs E AND G

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I. INTRODUCTION

In studying the problems of current interest in the area of galactic and solar cosmic rays, one of the basic needs is detailed charge and energy spectra over a wide dynamic range extending from the Mev to the Bev region for Hydrogen through the very heavy nuclei group. We would propose to do this on EGO missions with an integrated set of three detectors. The simultaneous observations of a significant portion of the cosmic ray spectrum with this set of detectors offers many unique advantages in understanding the problems related to the acceleration, propagation, and modulation of galactic and solar cosmic rays. The EGO mission offers an ideal opportunity to study the energetic particle population beyond the perturbing influence of the earth and its magnetosphere. Two of the detectors and their associated electronics are fully developed and have been flown on satellite and/or balloon flights. The third, for low energy particles, is a refinement of a design used successfully on Explorers XII and XIV. Flight experience has shown these detectors to be capable of accurate absolute intensity measurements over the indicated charge and energy intervals.

It is proposed that the corrected flux values would be made available to the scientific community on a reasonably fast time scale in much the same fashion that sea level neutron monitor data are now made available. Once the system is in operation, it is probable that this time scale would be of the order of six months after receipt of the data tapes.

The major scientific measurements to be made by this experiment are:

1. To measure the absolute proton flux and differential energy spectra over the range .4 - 1200 Mev and the integral flux greater than 1200 Mev.

2. To measure the absolute Helium flux and differential energy spectra over the range 2 - 1200 Mev/Nucleon and the integral flux greater than 1200 Mev/Nuc.

3. To measure the charge and differential energy spectra of the individual nuclear constituents in the interval Z = 3 - 20 in the range 20 Mev - 1200 Mev/Nuc and the integral flux greater than 1200 Mev/Nuc.

4. To measure the flux and differential energy spectra of 1 - 10 Mev solar and galactic electrons in the region beyond the magnetosphere.

5. To study the isotopic abundance of H, D, T, He^3 and He^4 in the interval 12 - 80 Mev/Nuc.

The primary scientific objectives are to study the properties of the galactic and solar cosmic radiation. We observe the galactic cosmic rays after they have undergone three basic processes: (1) initial acceleration, (2) diffusion and possible post-acceleration through the galaxy and (3) modulation by our own solar system. Each of these processes is important in its own right and the particle spectrum observed in the vicinity of the earth is a result of the superposition of these three effects. A detailed knowledge of the charge spectra should be important in understanding the initial acceleration mechanism. Flux measurements of D, He^3, and the Li, Be, and B group should provide three independent means of determining the average amount of material traversed by the primaries and, hence, their mean life time. Balloon measurements of Li, Be and B and He^3, although plagued by the background generated in the atmosphere above the balloon, indicate a mean amount of interstellar material traversed on the order of 3 - 8 gms. This amount of material should strongly modify the form of the low energy spectrum of medium, heavy and very heavy nuclei relative to the helium differential spectra. The observed spectral change should provide information on acceleration processes that might occur during diffusion through the galaxy.

By observing the local modulation over a significant fraction of a solar cycle, one would hope to better understand the processes by which the sun modulates the galactic cosmic rays. Closely related to this are short term fluctuations such as Forbush decreases and 27 day recurrent variations. The counting rates of all detectors should be sufficiently high to study the dynamics of these short term variations. The extended energy range is of special importance when studying the modulation processes. Most theories proposed to date contain several variables. Only by fitting the data over a wide energy range for particles of different charge to mass ratio can one decide among the various alternatives.

It will also be possible to study the complete arrival and propagation characteristics of solar cosmic rays for small and moderate size events (i.e., ~80% of all events). Of course, some information will be obtained from the largest events including early time of arrival data and information on the decay phase. The low energy detector (.4 - 8 mev for protons) will not saturate for any fluxes equal to those found in any previously studied event.

The study of solar cosmic rays over extended charge and energy ranges and with good time resolution should give information on both the acceleration process and on the dynamics of the propagation of these particles through space.

It also appears probable that many allied scientific fields such as astrophysics, ionospheric physics and radiation belt studies, are in need of reasonably precise galactic cosmic ray flux values as a function of time. In addition, it is probable that a thorough study may turn up new effects and processes that would greatly aid our understanding.

II. HISTORY OF RELATED COSMIC RAY MEASUREMENTS

Up to the launch of IMP-1, no definitive satellite or space probe measurements had been made on the primary cosmic rays. The Ion Chamber on Explorer VII, the single Cérenkov Counter on Ariel I, and the Double Scintillator on Explorer XII were all plagued to some degree with background problems and did not give adequate energy or charge resolution.

The University of Chicago's dE/dx vs Range experiment and the Goddard E vs dE/dx experiment on IMP-1 appear to be giving excellent charge and energy resolution for Hydrogen and Helium in the interval 15 - 90 Mev/Nuc.

These are extended through Oxygen on OGO A and B. The need for greater dynamic range in energy and Z is apparent.

While numerous balloon studies have been made of the charge and energy spectra in the region $Z \gtrsim 3$, these suffer from significant background corrections at all energies. The problems in the Hydrogen region at all energies due to secondaries and re-entrant albedo are well known. It would appear vital to have at least one series of precise space measurements to serve as a calibration for the balloon measurements. In addition, the studies can be extended to much lower energies in a satellite experiment because the detector can be located beyond the magnetosphere and above the absorbing atmosphere.

III DETECTOR SYSTEMS

It is proposed that the system will consist of three sets of detectors:

(a) A double-scintillator Cerenkov telescope for the interval 100 Mev/Nuc - 1200 Mev/Nuc.

(b) An E vs dE/dx telescope for the range 15 Mev/Nuc - 75 Mev/Nuc.

(c) A solid state detector with anti-coincidence cup for protons in the interval .4 - 8 Mev and Helium in the range 2 - 8 Mev/Nuc.

It might be possible to cover the complete energy range with 2 detector combinations but after detailed study we believe the three detector system to be superior in terms of charge and energy resolution and removal of ambiguity in the data. It is hoped to achieve an accuracy of $\pm$ 5% for the absolute intensity value with an average energy resolution of $\pm$ 10%.

A. Double-scintillation Cerenkov Telescope

Principle of Operation

Figure 1 shows the proposed telescope with its component parts. The two scintillation counters provide two separate measurements of the rate of ionization loss (dE/dx) and the Cerenkov counter measures the rate of production of Cerenkov radiation above the 350 Mev/Nuc threshold. Below this threshold in the range 100 to 350 Mev/Nuc the detector is used as a double scintillation counter telescope. Double coincidences between the scintillators define the geometrical acceptance aperture of the telescope. The two scintillation and the Cerenkov pulses enable us to identify the charge of the incident particle uniquely irrespective of its velocity over the indicated energy range. The consistency demanded between the two scintillation pulses helps in discriminating against background multiple particle events (due to showers, local nuclear interactions, etc.) and overlap below the Cerenkov threshold of slower particles of lower Z. Thus one can select genuine single particle traversals and attain unambiguous charge resolution.

The scintillation crystals of CSI are 1.0 gm/cm^2 thick and 5 cms. in diameter. Each of the crystals is viewed by an RCA C7151 photomultiplier. The Al foil reflector is very thin (.03 gm/cm^2) and separates the scintillators optically. The Cerenkov radiator is the 1 cm. thick quartz window of the photomultiplier. The top surface is blackened in order to discriminate against spacecraft secondaries.

The two scintillation counters are the defining elements of the telescope, giving a geometric factor of 3.4 cm^2-ster. For each particle that traverses these elements the outputs from the Cerenkov counter and the two scintillation counters are analyzed and recorded. The relationship between the measured outputs from the Cerenkov detector and the scintillation detector ($I_c \propto Z^2 (1 - 1/B^2n^2)$ and $I_s \propto Z^2/B^2$, where B = particle velocity, Z = charge of particle and n is the index of refrection of the Cerenkov medium) should uniquely determine the charge and velocity of the particle in question. In practice, it is possible to extend the measurement below the Cerenkov threshold by considering the two dE/dx measurements separately.

The inflight instrument calibration is straightforward. The relative position of the peaks of the ionization and Cerenkov distribution of relativistic helium and carbon nuclei are determined. This can be compared with the sea level μ meson calibration curve. The energy spectra of all charge groups can then be determined using the known linearity of the system and the theoretical variation of I_s and I_c with velocity. The 2nd scintillator is used to provide a self consistent check on the charge and energy of the particles as determined from the relative outputs of the Cerenkov detector and the other scintillation crystal. In addition, for low energies, a comparison of the outputs of the two scintillators gives an additional parameter to check the charge and energy, namely a measurement of the rate of energy loss of the particles at two different points on the trajectory. Experience has also shown that the second scintillator reduces the problem of background counts to negligible proportions. Since most of these "confusion" counts were due to nuclear interactions or knock-on electrons produced in the material of the detector itself, a greater degree of selection for these local events can be made by comparing the two scintillation outputs which reflect ionization loss conditions upon entrance and exit from the detecting system. Only events consistent with single particles traversing the system are used.

Historical Background

The detector proposed here is similar to that used by McDonald and Webber in 1958 which strongly reflected the experience gained with the Cerenkov scintillator since 1954. Similar designs have been sucessfully used by the University of Chicago group.

The prototype of this detector was flown in a Skyhook balloon in June, 1963 from Fort Churchill, Canada. The charge distribution obtained during one flight is shown in Figure 2. The proposed experiment will extend the charge spectrum to $Z = 20$. The heavy lines represent the theoretical variation of I_c and I_s. The end points of the lines drawn for each event represent the two measurements of dE/dx while a dot has been placed at the center point. Only those events have been selected for which the two dE/dx measurements differed by less than 33%. A small ($\sim$ 15%) correction is then applied for those which lie outside this range due to Landau fluctuations. The charge resolution obtained here is markedly superior to that obtained with nuclear emulsions. The preliminary alpha and proton rigidity spectra obtained during this flight are shown in Figure 3. Further analysis is in progress to extend this to 1200 Mev/Nuc. Agreement with nuclear emulsion values obtained at the same time is excellent.

B. E vs dE/dx Medium Energy Detector

Principle of Operation

The telescope consists of a combination of scintillators giving both the total energy of a charged particle (E) and its rate of energy loss (dE/dx). The operation of the detector can be seen from the schematic drawing (Figure 4). The actual telescope is shown in Figure 5. A CsI (Tl) crystal of 0.45 gm/cm^2 (1 mm) thickness measures a ΔE which is simply related to the rate of energy loss dE/dx. A second CsI (Tl) crystal of 9 gm/cm^2 (2 cm) thickness produces an output proportional to E - ΔE whenever the particle comes to rest in that crystal. A Pilot B plastic guard scintillator of thickness 0.8 gm/cm^2 surrounds the E - ΔE scintillator to determine whether the particle does or does not stop in the E - ΔE scintillator. The outputs of the ΔE and E - ΔE scintillators are analyzed only if light is observed from those two crystals but not from the guard scintillator. Thus, this detector is sensitive to those particles whose energies are high enough to penetrate the E crystal, yet low enough to be stopped in the E - ΔE scintillator. The crystal thicknesses are such that the energy range from 15 to 75 Mev per nucleon is covered.

The telescope has an acceptance angle defined by the ΔE and $E - \Delta E$ scintillators. (The geometric factor is 3.4 cm^2-ster). In the selection of the separation distance between these crystals and their diameters, two factors were of importance. Because of the expected low primary cosmic ray flux in this energy range the ratio of separation distance to diameter should be small and the diameter should be large to give a large geometric factor so that the rate of occurrence of acceptable events will be high. On the other hand, the ratio should be as high as possible to restrict the range in acceptance angle, in order to minimize the variation in path length in the ΔE scintillator and to minimize edge effects. A ratio of 2.0 has been chosen, giving an acceptance half angle of about 25 degrees and an acceptance solid angle of about 0.65 steradian. Thus the ratio of the longest to the shortest path lengths in the ΔE crystal (neglecting edge effects) is 1.12. The E and $E - \Delta E$ scintillators are 5 cm in diameter.

The characteristics of the detector are shown in Figure 6, where the energy loss in the ΔE crystal is plotted as a function of the energy loss in the $E - \Delta E$ crystal for electrons and various nuclei. The regions covered by this instrument are indicated in the figure. It can be seen that both the masses and energies of the particles can be ascertained if the light intensities in the two crystals are measured with sufficient accuracy. In using these curves to ascertain the properties of particles arriving from outside the instrument, corrections must be made for energy losses in the various light baffles.

Figure 5 also shows the manner in which the light is collected from the three scintillators. A light baffle having a total thickness of 25 mg/cm^2 is located between the ΔE and $E - \Delta E$ scintillators. An aluminum cup of thickness 27 mg/cm^2 optically separates the $E - \Delta E$ and guard scintillators.

Another light baffle of thickness 20 mg/cm^2 is located outside the E scintillator to exclude external light. All surfaces of the scintillators except those through which light must pass to reach the phototubes are covered with a diffusely reflecting adhesive consisting of a 50/50 mixture by weight of Emerson and Cuming, Inc., Stycast 1264 and titanium dioxide. Thus, light from the scintillators is reflected into light integrating cavities, which are viewed by the multiplier phototubes. The metallic surfaces of these optical cavities are coated with a diffusely reflecting paint. The most satisfactory reflecting surface is obtained by spraying a coating of type 29-915 High Reflectance White, made by E. I. du Pont de Nemours & Co. This paint contains a high concentration of titanium dioxide and is applied without an undercoating. The light is collected by three RCA type C-7151 multiplier phototubes, which are ruggedized versions of the type 6199 tube. They are operated with a cathode to anode potential of about 900 volts and with the cathodes at ground potential. The potentials between dynodes and between the tenth dynodes and anodes are equal, and the potentials between the photocathodes and the first dynodes are twice the dynode-dynode potentials.

<u>Proof Test of the E vs dE/dx Telescope Using Skyhook Balloon Flights</u>

A series of balloon flights were made during July, 1961, June, 1962 and June, 1963 using telescopes identical to those proposed for the satellite experiment. For the balloon flights the dE/dx and E signals were each recorded on 128 channel analyzers. For each event the two seven-bit words, representing dE/dx and E together with anti-coincidence signals from the third scintillator and timing information, were recorded on a miniature 16 channel tape recorder in the balloon gondola.

Figures 7 and 8 show the E vs. dE/dx measurements at 125,000 ft.

(4 gm/cm^2). On the high gain plot electrons, protons and deuterons are clearly represented. The proton and deuteron resolution is shown in Figure 7. Figure 8 shows the excellent alpha resolution. These data indicate a minimum of background in the proton and alpha region.

In addition, excellent proton, alpha, and electron resolution have been obtained from the IMP-1 detector which is identical to this one except it lacked the extended dynamic range planned here. It is hoped to extend the charge sensitivity through $Z = 20$.

C. Low Energy Solid State Detector

The low energy detector (Figure 9) is a large area (3 cm^2.) totally depleted solid state detector using the surface barrier technique to insure a minimum dead layer. Coupled to this is a plastic scintillator anti-coincidence counter which serves to define the solid angle (geometric factor 1.8 cm^2-ster). In addition, this anti-coincidence cup will greatly reduce the background flux arising from scattering and nuclear interactions in the spacecraft. It is felt this anti-coincidence feature will reduce the background flux by at least two orders of magnitude. Light shielding for the solid state detector and scintillator will be provided by a coating of 1000 Å aluminum and a 0.75 micron nickel foil. This is effectively the system used by Davis on Explorers XII, XIV and XV. It is felt that this constitutes a conservative light shield.

The experiment will perform a measurement of the total energy of each particle in the range .400 - 8 Mev/Nuc. The usual double-valued response of conventional solid state detectors is avoided by means of the anti-coincidence cup. This anti-coincidence feature also establishes a well defined path length in the solid state detector by virtue of the collimation. The response of the detector to protons and alphas is shown in Figure 10. It is observed there is proton-alpha overlap in the region 1 - 8 Mev total incident energy. On an energy per nucleon basis, both the galactic and solar cosmic rays probably have a p/α ratio of 7/1 although this is not well known. Thus, the alphas should not seriously alter the proton data in the region of overlap. The alpha region 8 - 32 Mev (2 - 8 Mev/Nuc) contains no protons. The regions of meaningful analysis are, therefore:

Protons	0.4 - 8 Mev
Alphas	2 - 8 Mev/Nuc

Electrons which directly traverse the crystal will lose about 20 Kev if they do not scatter. This is a factor of 8 below the electronic circuit threshold. It is felt that scattering will not be a problem because the detector is constructed of low Z material, and scattering resulting in a factor of 8 increase in the path length will most probably result in some traversal into the anti-coincidence cup.

The solid state detector pulses will be fed into a pulse height analyzer. This will provide about 150 Kev resolution over the region .4 - 32 Mev. In addition, the output of an eight level integral spectrum analyzer will be scanned by a count rate channel.

Two modes of operation of this portion of the experiment will be provided on a time sharing basis:

(1) G$\bar{H}$ (see Fig. 3) This is the method outlined above in which all particles that penetrate to the anti-coincidence cup are rejected.

(2) G only. In this mode the anti-coincidence cup is disabled. The second mode is intended primarily for use during periods of very high counting rate following solar flares. Mechanical collimation

is then provided by the plastic cup.

With 0.25 μ-sec pulse resolution provided by the pulse shaping circuit and good overload characteristics on the amplifiers, it is felt that one could readily measure fluxes as great as those encountered during the 12 Nov. 1960 event. This event probably represents the largest low energy event observed to date.

History of Previous Work

Much of the design philosophy of the experiment proposed here is based on the experience obtained from the low energy proton experiment on Explorers XII and XIV. This detector, covering the energy internal 1.5 to 19 Mev, was invaluable during solar cosmic ray events and responded readily to the moderate-sized solar events encountered with a reserve of two orders of magnitude. It also clearly illustrated the importance of a large area detector in measuring the extremely low flux value of the recurrent solar cosmic ray events. The background encountered in the Explorer XII detector in the 3 - 19 Mev region was twice the counting rate due to cosmic rays of <u>all energies</u>. Clearly, an active anti-coincidence device is necessary to cover a possible galactic contribution in the very low energy range.

The techniques employed in the proposed experiment are similar to those employed in the Mariner B electron - proton experiment built by this group. This detector employed a thin solid state detector, total E scintillator, and guard scintillator to detect nuclei in the energy range 9.5 to 50 Mev per nucleon and electrons in the energy range 0.6 to 3.0 Mev. The prototype detector was fabricated, calibrated, and environmentally tested, but the program was cancelled. The presently proposed experiment represents a simplification of that instrument and the use of a thinner, higher quality solid state detector. The new solid state detector is readily available as a commercial item and suitable samples are currently in operation in our laboratory. Because of our previous work in this area and the state of availability of all components, we consider the state of development of this experiment to be essentially complete.

IV. DESCRIPTION OF THE ELECTRONIC SYSTEM

The complete instrument is shown in block diagram form in Figure 11. The high, medium, and low energy telescopes operate with three independent pulse height analysis systems. In each of these the P.M.tube pulses are amplified and shaped by delay line pulse shapers to prevent pulse pile-up. The solid state detector output is amplified by a charge sensitive amplifier and shaped. The shaped pulse heights are converted into binary numbers by the pulse height analyzers (P.H.A.'s) whenever the coincidence requirements are met and the analyzers are not "busy". The analyzers are made "busy" from the time an analysis begins to the time the resultant numbers are read into the spacecraft data handling and storage system.

Readout by the spacecraft occurs approximately 1, 8 or 64 times per second, depending on the spacecraft bit rates in use. Thus, the analyzer systems will be able to analyze approximately 1, 8 or 64 particles meeting their respective acceptance requirements in each second. When the fluxes of acceptable particles exceed these values, the instrument will analyze a random sample of the total flux. Flux values will be provided by the rate channel. This channel consists of an accumulator with a commutator at its input to sequentially sample a number of detector coincidence rates as indicated in the block diagram. Since the rate measuring accumulator has a dead time of only about one microsecond, accurate flux information will be obtained for very high flux values. The rate accumulator is a floating point accumulator with a count capacity of more than 2×10^6 and a fixed accuracy of 3%. This permits a large dynamic range and fixed accuracy with a minimum amount of transmitted data.

In addition, the low energy detector will provide spectral information during high-flux events by the use of an eight level integral spectrum analyzer whose outputs are counted sequentially by the commutator.

The scintillator-Cérenkov and dE/dx vs E telescopes require analysis over a large range of pulse heights with good resolution in the lower energy regions. This requirement is met by using 256 channel analyzers and two gain settings for the amplifiers preceding the converter sections. The proper amplifier gains are selected by threshold circuits, and indicators showing the gain settings are inserted in the data. With 256 channel analyzers and a factor of 8 difference in gain the ratio of maximum energy to low channel energy interval is about 2000. This two gain system was pioneered by this group and has been employed in analyzers on several balloon flights and in the OGOs A and B experiments.

The complete system employs a very large number of components. For the sake of reliability, it has been separated into several independent subsystems. These are interconnected in such a manner that the failure of single components or groups of components cannot cause failure of the complete system. Two independent high voltage converters will be used, one for the scintillator-Cérenkov telescope and one for the dE/dx vs E and low energy detectors. The analyzer systems following the three detectors are completely independent. Two low voltage converters and two accumulator, readout, and readout control systems will be used. Cross-strapping will be employed to give higher system reliability than would be obtained by separating the system into two completely independent instruments.

V. SPACECRAFT INTERFACE INFORMATION

A. Physical configuration. The entire instrument will be packaged in a single container having a maximum size of 8 inches high, 18 inches wide, 8 inches deep. Two cylindrical protrusions on the rear side (away from the mounting surface) will be approximately 3 inches in diameter and 4 inches long.

B. Mounting location. The experiment should be mounted in the spacecraft main body. The side facing away from the earth is preferred. It will fit on 2 1/4 door modules in the deep section of the main body.

C. Field of view. There should be no physical obstructions within cones having 45° half angles centered at the detector openings.

D. Weight. The total weight of the instrument will be 21.9 pounds or less. The total weight consists of the following:

Item	Weight
Main Container	4.0
Scintillator-Cerenkov telescope	4.0
dE/dx vs E telescope	3.2
Low E proton-alpha detector	1.3
High Voltage Converters (2)	1.2
Low Voltage Converters (2)	1.0
Preamplifiers (7)	0.1

Item	Weight
Pulse Height Analyzers (6)	2.6
Coincidence and PHA control circuits (3)	1.2
Accumulators, Readout, and Readout Control Circuits (2)	2.0
Temperature Measuring Circuits	0.1
Interconnect Wires, Connectors, and Misc.	1.2
TOTAL	21.9

E. Power requirement. The total operating input power, including that required for converter losses is 4.5 watts. It will be essentially constant regardless of operating mode or particle flux intensities.

F. Thermal characteristics. The heat generated in the instrument can be easily dissipated through the 8 by 18 inch door mounting area and by radiative transfer inside the main body. Three circular door openings about 3 inches in diameter for the detectors will be required. Aluminized mylar can be located over two of the openings to reduce solar heat input as was done in our experiments on OGOs A and B. It is essential that the low energy detector assembly be directly exposed to the externally incident particles.

G. Telemetry requirements. We desire 8 digital words in the main commutators in each of the two equipment groups. First preference is for these to be arranged in two groups of 4 words each. If this is not possible, then we need three groupings of 3, 3, and 2 respectively. The word assignments should be the same in both equipment groups to facilitate data processing on the ground.

Three subcommutator analog words in each equipment group are requested for measurement of the detector temperatures. These can be located arbitrarily in the formats, but should be the same in both equipment groups.

No use of flexible format is contemplated.

H. Commands. One power command in our main power lead and three impulse commands for failure mode switching are requested.

I. Spacecraft signals. The following spacecraft signals are required:

1. Inhibit signals - 16 as required in G
2. Shift signals - 2 as required in G
3. Switch signal
4. Mode signal
5. 2461 cps power converter sync signal

J. Interfering sources within the instrument. There will be 3 very low level 0.5 Mcs crystal oscillators located within the experiment. All power converters will be synchronized at 2461.5 cps. No on-board radioactive sources are contemplated. The magnetic field produced by the complete assembly will be less than 0.1 gamma at the end of either long boom.

K. Susceptibility to interference. This experiment will be susceptible to interference from radioactive sources located in the observatory. The flux of gamma and X-rays due to local sources should be less than one per cm^2 per ten seconds at the location of this experiment. Direct electrons produced by local sources are not expected to interfere.

VI. PRESENT STATE OF INSTRUMENT DEVELOPMENT

Major portions of the experiment have been used on previous flights by this group. The preamplifiers, pulse height analyzers, coincidence and PHA control circuits, binary accumulators, floating point accumulators with their commutators, readout and control circuits, and high and low voltage converters perform functions identical to similar devices in our present IMP-1 and OGO-A experiments. Slight modifications of the IMP and OGO circuits are being made to improve performance and reduce the weight and size requirements as a reflection of our experience with the earlier experiments. The most significant change is a redesign of the accumulator, readout, and readout control circuits in thin film or integrated circuit form to effect a dramatic weight and power saving. As a result of our extensive past experience with these detectors, electronic circuits and the OGO system, we feel that the weight, power, and size figures listed earlier are realizable with a high certainty.

VII. DATA ACQUISITION

We desire data acquisition by the use of the on-board tape recorders at the one kilobit rate continuously. Recovery of higher bandwidth data at 8 and 64 kilobits is desirable periodically, especially to improve the statistical accuracy for special high flux events. It is estimated that high bit rate data will not be necessary more than 10% of the time. We will have special interest in high bit rate data during and following solar storms.

SUMMARY

An integrated set of three detectors is proposed to study the properties of the galactic and solar cosmic rays.

These detectors are:

A. A double-scintillator Cerenkov Telescope measures the charge and differential energy spectra of the individual nuclear constituents of charge Z = 1 - 20 in the range 100 Mev/Nuc to 1200 Mev/Nuc and the integral flux greater than 1200 Mev.

B. E vs dE/dx detector for electrons of 1-10 Mev and H, D, T, He^3 and He^4 and Z = 3 - 20 in the range $\sim$15 Mev/Nuc - 75 Mev/Nuc.

C. Low energy solid state detector with anticoincidence cup proton .4 - 8 Mev and Helium 2 - 8 Mev/Nuc.

Experiment Weight: 21.9 lbs

Power: 4.5 watts

Physical Size: 8" x 8" x 18"

Mounting: Spacecraft main body on side looking away from earth.

Telemetry Requirement: 8 digital words in the main commutator in each of the two equipment groups.